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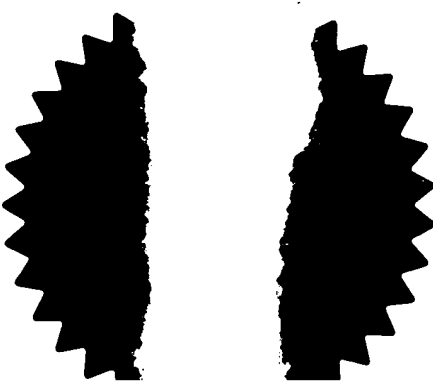
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# Patents Form 1/77

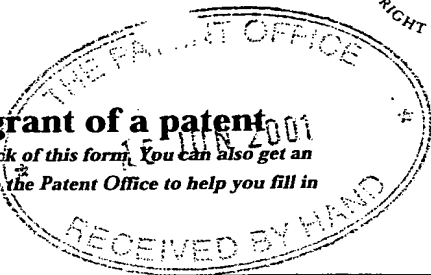
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# 1/77

## Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)



The Patent Office

Cardiff Road  
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1. Your reference	SG/P8148GB			18JUN01 E637773-1 000571
				DAY '7700 0.00-0114684.4
2. Patent application number (The Patent Office will fill in this part)	<b>0114684.4</b>			15 JUN 2001
3. Full name, address and postcode of the or of each applicant (underline all surnames)	Dow Chemical Company Limited 2 Heathrow Boulevard 284 Bath Road West Drayton Middx UB7 0DQ	Dow Deutschland GmbH & Co. OHG Am Kronberger Hang 4 65824 Schwalbach Germany		
Patents ADP number (if you know it)	413971005	8168502001		
If the applicant is a corporate body, give the country/state of its incorporation	United Kingdom	Germany		
4. Title of the invention	AUTOMOBILE ASSEMBLY			
5. Name of your agent (if you have one)	W. H. Beck, Greener & Co.			
"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)	W. H. Beck, Greener & Co. 7 Stone Buildings Lincoln's Inn London WC2A 3SZ			
Patents ADP number (if you know it)	323001			
6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number	Country	Priority application number (if you know it)	Date of filing (day / month / year)	
7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application	Number of earlier application		Date of filing (day / month / year)	
8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if: a) any applicant named in part 3 is not an inventor, or b) there is an inventor who is not named as an applicant, or c) any named applicant is a corporate body. See note (d))	YES			

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9. Enter the number of sheets for any of the following items you are filing with this form.  
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Continuation sheets of this form

Description	16
Claim(s)	4
Abstract	1
Drawing(s)	1 + 1

10. If you are also filing any of the following, state how many against each item.

Priority documents

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77)

Request for preliminary examination and search (Patents Form 9/77)

1

Request for substantive examination (Patents Form 10/77)

Any other documents (please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

*W H Bode, Engineer & Co.*

Date 15.06.01

12. Name and daytime telephone number of person to contact in the United Kingdom

Mr. Stephen Geary - (020) 7405 0921

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## AUTOMOBILE ASSEMBLY

This invention relates to an automobile assembly, in particular to structural assemblies employed at the front end known as a "front end carrier" or rear end of an automobile.

A "Front end carrier" (hereafter FEC) for an automobile is that part of the body of the automobile which joins the two sides of the front of the automobile together and is aligned transversely so as to enclose a front, typically engine, compartment. The FEC is shaped for aesthetic and functional purposes, and typically houses or is otherwise used to carry one or more of the lighting assemblies, the cooling system and the latch by which the bonnet is secured when closed.

FEC's conventionally are made of at least two parts, a structural member and a reinforcing member.

Usually, the structural member comprises a plastics material, for example polypropylene, glass filled polypropylene or polyamides, which lends itself to shaping in the desired form. The plastics part of the FEC is conventionally produced by moulding using known techniques including compression moulding and injection moulding.

The reinforcing member is employed to provide impact resistance, as well as providing structural benefits such as improved durability and stiffness. The reinforcement is typically made of a metal, for example steel and aluminium, but may be made from other materials capable of providing reinforcement.

The reinforcement is typically attached to the plastic moulding by mechanical fixing, for example using bolts and screws. However mechanical fixing causes concentrations of stress at the fixing points between the plastic moulding and the reinforcement, which may cause the FEC to fail mechanically during durability testing.

As an alternative to mechanical fixing, the plastic moulding may be moulded around and interlock with the reinforcement for instance by way of providing holes

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in the reinforcements and forming the plastic moulding in situ so as to secure the two parts together. This process nevertheless is more expensive than assembling the plastic moulding and reinforcement using mechanical fixing and also provides less process flexibility. Furthermore, the design and effectiveness in use of the reinforcement may be compromised by having multiple holes and structurally less effective geometry which are needed to permit in situ formation of the plastic moulding.

Traditional adhesives do not bond effectively to plastics materials of the type used in FECs due to the low surface energy of the plastic materials. As such it is believed adhesives have not hitherto been employed for fabricating FECs and the like.

Adhesives for use in bonding to low surface energy materials are however known. For example US-A-5795657 discloses adhesive compositions which are said to have excellent adhesion to a variety of substrates especially low surface energy polymers. The adhesive disclosed in this document relates to organoborane polyamine complexes and especially complexes wherein the polyamine is reaction product of dye primary amine terminated material and material having at least two groups reactive with primary amine with an excess of primary amine groups over groups reactive with primary amine. The complexes may be used in systems that initiate the polymerisation of acrylic monomer to yield acrylic adhesive compositions. Such compositions are said to be useful for bonding low surface energy plastic or polymer substrates. US-A-5795657 refers to organoborane amine complexes used in acrylic adhesives and which may be employed in structural and semi-structural applications including (automotive) glass/metal bonding and bonding other types of materials together. Reference is made to bonding plastic to a range of types of materials of which one is metal.

US-A-5691065 relates to organoborane amine complexes and to acrylic adhesives that incorporate initiator systems based on such complexes. The adhesives are especially useful in bonding low surface energy substrates such as polyethylene, polypropylene and polytetrafluoroethylene. In the Examples in this

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document Examples 14 to 118 provide data concerning adhesion to a polyethylene substrate or a polytetrafluoro-ethylene substrate. Examples 121 to 125 additionally include reference to adhesion of a polypropylene substrate which is bonded to a substrate of the same material.

5        These prior art documents do not contemplate the use of adhesives to bond reinforcing components to plastic mouldings in automobile applications in which a combination of practical and technical criteria must be met.

10        In view of the widespread consumer use of automobiles, matters of safety, such as improved crash resistance, durability and stiffness of the FEC, and also of cost and manufacturing flexibility are critical in the design and manufacture of automobiles.

15        The known technique of mechanical fixing of the reinforcement to the plastic moulding has drawbacks as regards structural limitations, and stress concentrations and forming the FEC by moulding the plastic in situ, for example through holes in the reinforcement, is costly and inflexible which may limit design options and also increase costs of production. Producing the FEC by in situ moulding around the reinforcement also requires the moulding tool to have a complementary design to the reinforcing component so any changes in the design of the reinforcing component require modifications to the moulding tool hence  
20        introducing further process complication and cost. A need remains therefore to improve the optimum combination of safety, cost and manufacturing flexibility.

25        We have now found a method by which the reinforcement may be attached to the plastic moulding in automobile assemblies such as FECs which ameliorates or removes the drawbacks associated with existing methods of producing them. By employing certain types of adhesive which are capable of bonding to low energy surfaces such as plastics materials used in FECs, the need for attachment through mechanical fixing or in situ formation of a plastic moulding around a reinforcing component may be reduced or avoided.

30        Accordingly, a first aspect of the invention provides a method for producing an automobile assembly comprising a structural member made of a moulded

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plastics material having a low energy surface and a reinforcing member attached to the structural member, the members having complementary surfaces, which comprises applying an adhesive to the complementary surface of the structural member and/or reinforcing member, bringing the complementary surfaces of the reinforcing member and structural member into contact and allowing the adhesive to set so as to bond the structural member and reinforcing member together wherein the adhesive is capable of bonding to a low energy surface plastic.

By low energy surface plastic is meant materials that have a surface energy of less than  $45 \text{ mJ/m}^2$ , suitably less than  $40 \text{ mJ/m}^2$  and desirably less than  $35 \text{ mJ/m}^2$  including, by way of example polypropylene and polyamide. If desired, the surface of the structural member and/or reinforcing member may be treated or primed to improve adhesion prior to application of the adhesive. Suitably the structural member is not subjected to treatment or priming and the adhesive is applied directly to the surface of the structural member.

In a second aspect, the invention provides for the use of an adhesive capable of bonding to a low energy surface substrate in the fabrication of an automobile assembly which comprises a structural member comprising a plastic moulding having a low energy surface and a reinforcing member to bond together the said moulding and reinforcing member.

In a third aspect, the invention provides an automobile assembly comprising a structural member made of a moulded plastics material having a low energy surface and a reinforcing member attached to the structural member, the structural member and reinforcing member having complementary surfaces and being attached by means of an adhesive, which is capable of bonding to a low energy surface substrate, on at least part of one or both of the complementary surfaces.

Advantageously, the invention permits the structural member and the reinforcing member to be attached after the structural member has been produced so avoiding the drawbacks of the known process in which the structural member is formed in situ. Thus the risk of having to alter the tools for producing the structural member if the reinforcing member design alters is reduced. Further, the design

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and hence structural effectiveness of the reinforcing member is not compromised by limitations on the geometry, shape or dimensions of the reinforcing member imposed by the tooling apparatus. The invention accordingly provides advantages as regards enhanced process flexibility, design of the assembly and cost. In addition reinforcements of a complex design may be employed to provide a higher level of reinforcement per unit weight of reinforcement. This arrangement may provide additional benefits as regards design flexibility, reduced weight with the advantages that flow from that.

In a preferred embodiment, the structural member and reinforcing member have complementary shapes, at least in part and they are bonded together by application of adhesive on either or both of the complementary parts of the members so as to bond the two parts together over an area which is significantly greater than the area associated with joining the parts by mechanical fixing. Advantageously, bonding the structural member and reinforcing member in this manner reduces the concentration of stress at the joints between the two members. Preferably, the structural member and reinforcing member are bonded together by a continuum of adhesive along the complementary surfaces on the two members in order to reduce the concentration of stress at a particular point when load is applied to the assembly.

The automobile assembly, for example FEC, is suitably manufactured employing known techniques for producing the structural member for example compression or injection moulding.

Suitably the structural member comprises a plastic moulding. The plastics material preferably comprises a homopolymer, for example a polyolefin, a polyamide, a polyphenylene oxide and a polystyrene, or a copolymer, for example a polyalkylene terephthalate, having a low surface energy.

Preferred plastics materials include polypropylene, polyamide, polyamide alloys, polyphenylene oxide polymers, polyphenylene oxide alloys, polystyrene polymers, polystyrene alloys, polybutylene terephthalate polymers and

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polybutylene terephthalate alloys. The plastics material may contain fibre, for example short glass fibre, long glass fibre, short natural fibre or long natural fibre.

Especially preferred plastics materials include short glass fibre filled polypropylene, long glass fibre filled polypropylene, glass filled polyamide and  
5 glass filled polyamide alloys.

The reinforcing member is suitably made of a metal, for example steel, zinc and aluminium, but may be made from other materials capable of providing reinforcement. The reinforcing member may be coated with materials typically employed in the manufacture of automobiles, for example anti-corrosion materials  
10 and primers for additional coatings such as paint.

In an especially preferred embodiment of the invention, the structural member is made from glass filled polypropylene and/or glass filled polyamide and the reinforcing member is made from steel or aluminium.

The present invention may be applied to any automobile assemblies in  
15 which a material is to be bonded to a low energy surface material for example "front end" systems and "rear end" systems.

The reinforcing member and/or structural member may be provided with contours or channels which are complementary with the surface of the other member so as to provide improved contact and alignment between the structural  
20 and reinforcing members. Shaping the members suitably provides enhanced resistance to stresses as the adhesion between the members may be supplemented by physical abutment depending on the direction in which the stress is applied.

The adhesive employed in the present invention must be able to bond a low  
25 energy surface substrate and also act to bond a second substrate to the low energy surface substrate and, preferably is a polymerisable composition.

In a preferred method the structural member and reinforcing member are bonded together by providing an adhesive comprising a polymerisable composition, contacting together the components of the adhesive under conditions  
30 for initiating polymerisation of the adhesive, applying the adhesive to the

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complementary surface of the structural and/or reinforcing member, bringing the complementary surfaces of the reinforcing member and structural member into contact and curing the adhesive so as to bond the said members together.

Initiating polymerisation of the adhesive may be carried out prior to or after application of the adhesive to one or both members or during application or as a result of application of the adhesive to one or both members.

In a preferred embodiment, the adhesive comprises a polymerisable composition comprising an organoborane/amine complex and one or more of monomers, oligomers or polymers having olefinic unsaturation which is capable of polymerisation by free radical polymerisation. Optionally, the adhesive may additionally comprise a compound which causes the said complex to disassociate so as to release the borane to initiate polymerisation of one or more of monomers, oligomers or polymers having olefinic unsaturation. Where a compound which causes the complex to disassociate is employed, it is kept separate from the complex until initiation of polymerisation is desired. The polymerisable composition which contains the disassociating agent may be cured at any desired temperature, such as at, or near, ambient temperature and below ambient temperature.

An especially preferred embodiment of the invention provides an automobile assembly comprising a structural member made of a moulded glass filled polypropylene and/or glass filled polyamide having a surface energy of less than  $45 \text{ mJ/m}^2$ , and a reinforcing member made from steel, zinc and/or aluminium attached to the structural member, the structural member and reinforcing member having complementary surfaces and being attached by means of an adhesive which is capable of bonding to a substrate having a surface energy of less than  $45 \text{ mJ/m}^2$  disposed between at least part of the complementary surfaces so as to bond them together, the adhesive being derived from a polymerisable composition comprising

i) an organoborane/amine complex;

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ii) one or more of monomers, oligomers or polymers having olefinic unsaturation which is capable of polymerisation by free radical polymerisation; and, optionally

5 iii) a compound which causes the said complex to disassociate so as to release the borane to initiate polymerisation of one or more of monomers, oligomers or polymers having olefinic unsaturation.

Additional especially preferred aspects of the invention are a method of making the automobile assembly referred to in the preceding paragraph and use of an adhesive described in that paragraph in fabricating the assembly described  
10 in it.

Adhesives and polymerisable compositions disclosed in International Patent Application No. PCT/US00/33806 are especially preferred for use in the present invention to bond the structural member and reinforcing member together.

The amines used to complex the organoborane compound can be any  
15 amines which complex the organoborane and which can be decomplexed when exposed to a decomplexing agent. Preferred amines include the primary or secondary amines or polyamines containing primary or secondary amine groups, or ammonia as disclosed in Zharov US 5,539,070 at column 5 lines 41 to 53, incorporated herein by reference, Skoultchi US 5,106,928 at column 2 line 29 to  
20 58 incorporated herein by reference, and Pocius US 5,686,544 column 7, line 29 to Column 10 line 36 incorporated herein by reference; monthanolamine, secondary dialkyl diamines or polyoxyalkylenepolyamines; and amine terminated reaction products of diamines and compounds having two or more groups reactive with amines as disclosed in Deviny US 5,883,208 at column 7 line 30 to column 8  
25 line 56, incorporated herein by reference. With respect to the reaction products described in Deviny the preferred diprimary amines include alkyl diprimary amines, aryl diprimary amines, alkyaryl diprimary amines and polyoxyalkylene diamines; and compounds reactive with amines include compounds which contain two or more groups of carboxylic acids, carboxylic acid esters, carboxylic acid halides,  
30 aldehydes, epoxides, alcohols and acrylate groups. Preferred amines include n-

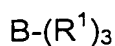
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octylamine, 1,6-diaminohexane (1,6-hexane diamine), diethylamine, dibutyl amine, diethylene triamine, dipropylene diamine; 1,3-propylene diamine (1,3-propane diamine), 1,2-propylene diamine, 1, 2-ethane diamine, 1,5-pentane diamine, 1,12-dodecanediamine, 2-methyl-1,5-pentane diamine, 3-methyl-1,5-pentane diamine, 5 triethylene tetraamine, diethylene triamine. Preferred polyoxyalkylene polyamines include polyethyleneoxide diamine, polypropyleneoxide diamine, triethylene glycol propylene diamine, polytetramethyleneoxide diamine and polyethyleneoxidecopolypropyleneoxide diamine.

In particular, the amine in the organoborane/amine complex is suitably  
 10 selected from the group of amines having an amidine structural component; aliphatic heterocycles having at least one nitrogen in the heterocyclic ring wherein the heterocyclic compound may also contain one or more nitrogen atoms, oxygen atoms, sulphur atoms, or double bonds in the heterocycle; primary amines which in addition have one or more hydrogen bond accepting groups wherein there are  
 15 at least two carbon atoms, preferably at least three carbon atoms, between the primary amine and the hydrogen bond accepting group, such that due to inter- or intramolecular interactions within the complex the strength of the B-N bond is increased; and conjugated imines.

Preferred hydrogen bond accepting groups include the following: primary  
 20 amines, secondary amines, tertiary amines, ethers, halogens, polyethers or polyamines. Heterocycle as used herein refers to a compound having one or more aliphatic cyclic rings of which one of the rings contains nitrogen. The amidines or conjugated imines may be straight or branched chain or cyclic.

Desirably, the organoborane used in the complex is a trialkyl borane or an  
 25 alkyl cycloalkyl borane. Preferably this borane corresponds to Formula 1:



Formula 1

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wherein B represents boron; and  $R^1$  is separately in each occurrence a  $C_{1-10}$  alkyl,  $C_{3-10}$  cycloalkyl, or two or more of  $R^1$  may combine to form a cycloaliphatic ring.

Preferably  $R^1$  is  $C_{1-4}$  alkyl, even more preferably  $C_{2-4}$  alkyl and most preferably  $C_{3-4}$  alkyl. Among preferred organoboranes are tri-ethyl borane, tri-isopropyl borane and tri-n-butylborane.

In a preferred embodiment, the amine part of the complex comprises a compound having a primary amine and one or more hydrogen bond accepting groups, wherein there are at least two carbon atoms, preferably at least about three, between the primary amine and hydrogen bond accepting groups.

Preferably, the amine corresponds to Formula 2:



wherein:

$R^2$  is separately in each occurrence hydrogen or a  $C_{1-10}$  alkyl or  $C_{3-10}$  cycloalkyl; X is hydrogen bond accepting moiety; a is an integer of 1 to 10; and b is separately in each occurrence an integer of 0 to 1, and the sum of a and b is from 2 to 10.

Preferably  $R^2$  is hydrogen or methyl.

Preferably X is separately in each occurrence a hydrogen accepting moiety and, when the hydrogen accepting moiety is an amine, it is preferably a tertiary or a secondary amine. More preferably X is separately in each occurrence  $-N(R^8)_e$ ,  $-OR^{10}$ , or a halogen wherein  $R^8$  is separately in each occurrence  $C_{1-10}$  alkyl,  $C_{3-10}$  cycloalkyl or  $-(C(R^2)_2)_d-W$ ;  $R^{10}$  is separately in each occurrence,  $C_{1-10}$  alkyl,  $C_{3-10}$  cycloalkyl, or  $-(C(R^2)_2)_d-W$ ; and e is 0, 1, or 2. More preferably X is  $-N(R^8)_2$  or  $-OR^{10}$ .

Preferably,  $R^8$  and  $R^{10}$  are  $C_{1-4}$  alkyl or  $-(C(R^1)_2)_d-W$ , more preferably  $C_{1-4}$  alkyl and most preferably methyl. W is separately in each occurrence hydrogen or  $C_{1-10}$  alkyl or X and more preferably hydrogen or  $C_{1-4}$  alkyl.

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Preferably, a is about 1 or greater and more preferably 2 or greater. Preferably a is about 6 or less, and most preferably about 4 or less. Preferably, b is about 1. Preferably, the sum of a and b is an integer about 2 or greater and most preferably about 3 or greater. Preferably the sum of a and b are about 6 or less and more preferably about 4 or less. Preferably d is separately in each occurrence an integer of 1 to 4, more preferably 2 to 4, and most preferably 2 to 3.

Among preferred amines corresponding to Formula 2 are dimethylaminopropyl amine, methoxypropyl amine, dimethylaminoethylamine, dimethylaminobutylamine, methoxybutyl amine, methoxyethyl amine, ethoxypropylamine, propoxypropylamine, amine terminated polyalkylene ethers (such as trimethylolpropane tris(poly(propyleneglycol), amine terminated)ether), aminopropylmorpholine, isophoronediamine, and aminopropylpropanediamine.

In another embodiment, the amine may be an aliphatic heterocycle having at least one nitrogen in the heterocycle. The heterocyclic compound may also contain one or more of nitrogen, oxygen, sulfur or double bonds. In addition, the heterocycle may comprise multiple rings wherein at least one of the rings has a nitrogen in the ring. Preferred compounds of this type include morpholine, piperidine, pyrrolidine, piperazine, 1,3,3 trimethyl 6-azabicyclo[3,2,1] octane, thiazolidine, homopiperazine, aziridine, 1,4-diazabicyclo[2.2.2]octane (DABCO), 1-amino-4-methylpiperazine, and 3-pyrroline.

In yet another embodiment, the amine which is suitably complexed with the organoborane is an amidine. Any compound with amidine structure wherein the amidine has sufficient binding energy as described hereinbefore with the organoborane, may be used. Among preferred amidines are 1,8 diazabicyclo[5,4]undec-7-ene; tetrahydropyrimidine; 2-methyl-2-imidazoline; and 1,1,3,3-tetramethylguanidine.

In a further embodiment, the amine which is complexed with the organoborane is suitably a conjugated imine. Any compound with a conjugated imine structure, wherein the imine has sufficient binding energy with the organoborane as described in International Patent Application No.

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PCT/US00/33806 may be used. The conjugated imine can be a straight or branched chain imine or a cyclic imine. Among preferred conjugated imines are 4-dimethylaminopyridine; 2,3-bis(dimethylamino)cyclopropeneimine; 3-(dimethylamine)acroleinimine; 3-(dimethylamino)methacroleinimine.

5            Preferably the molar ratio of amine compound to organoborane compound is from 1.0:1.0 to 3.0:1.0. Below the ratio of about 1.0:1.0 there may be problems with polymerisation, stability of the complex and adhesion. Greater than about a 3.0:1.0 ratio may be used although there may not be additional benefit from using a ratio greater than about 3.0:1.0. If too much amine is present, this may  
10           negatively impact the stability of the adhesive or polymer compositions. Preferably the molar ratio of amine compound to organoborane compound is from 2.0:1.0 to 1.0:1.0.

            The organoborane amine complex may be readily prepared using known techniques, for example as described or referred to in International Patent  
15           Application No. PCT/US00/33806.

            Preferably, the polymerisable material comprises acrylate and/or methacrylate based compounds. Especially preferred acrylate and methacrylate compounds include methylmethacrylate, butylmethacrylate, ethylhexylmethacrylate, isobornylmethacrylate, tetrahydrofurfuryl methacrylate,  
20           and cyclohexylmethylmethacrylate.

            The polymerisable composition may further comprise an effective amount of a compound that is reactive with an amine so as to liberate the organoborane so as to initiate polymerisation (a disassociating agent). Desirable amine reactive compounds are those materials that can readily form reaction products with  
25           amines at or below and more preferably at room temperature so as to provide a composition that can be generally easily used and cured under ambient conditions. General classes of these compounds include acids, aldehydes, isocyanates, acid chlorides, sulphonyl chlorides, mixtures thereof and the like. Preferred amine reactive compounds are acids, especially Bronsted and Lewis

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acids and those described in US-A- 5718977 and, more desirably acrylic acid and methacrylic acid.

In the polymerisable composition, suitably at least 20% by weight, preferably at least 30 % by weight and especially at least 40 % by weight of the composition comprises the polymerisable component. Independently, the polymerisable component is suitably present at a level not exceeding 95%, preferably not exceeding 90% and especially not exceeding 85% by weight of the composition.

Suitably, the organoborane/amine complex is present at a level of at least 0.2%, preferably at least 1% and more preferably at least 2% by weight of the composition. Independently, the complex is suitably present at a level not exceeding 8%, preferably not exceeding 6% and especially not exceeding 4% by weight of the composition.

If present, the disassociating compound is present at a level of at least 1%, preferably at least 1.5% and more preferably at least 2% by weight of the composition. Independently, the disassociating compound is suitably present at a level not exceeding 8%, preferably not exceeding 6% and especially not exceeding 4% by weight of the composition.

The adhesive to be employed in the present invention suitably is capable of providing a bond between a 30% glass filled polypropylene structural member and the reinforcing member without the structural member having been subjected to any surface treatment when tested in accordance with the procedure set out in ASTM D1002. Preferably, the adhesive provides a bond when tested under this regime including in addition being subjected to thermal cycling and high humidity. Thermal cycling in this context suitably includes cycling over a range from  $-40^{\circ}\text{C}$  to greater than  $120^{\circ}\text{C}$ . Humidity levels can vary from dry to fully saturated.

The adhesive may be used in the manner set out in International Patent Application No. PCT/US00/33806. Optionally, further components may be included as additives in the composition. Suitable additives include those set out in International Patent Application No. PCT/US00/33806.

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The assembly suitably is able to withstand exposure to heat at a temperature of 100°C and suitably at up to 120°C or more. Further, the assembly desirably should also be able to withstand loads applied during production and also imposed in use, for example by slamming the bonnet, application of load to the bonnet latch and vibration and fatigue during use due to displacement from the road surface. The amount and location of adhesive is suitably selected having regard to the design and structure of the automobile to which the application applies.

In fabricating the assembly, the adhesive composition is suitably applied to one or both of the members in those areas which are to be joined. The adhesive is suitably cured at ambient temperature and curing preferably is initiated prior to the members being brought together. The members are then suitably contacted while the adhesive remains able to bond the two members, for example, as the adhesive becomes tacky. If desired, the members may be held in place by mechanical means for example, snap-fits, mechanical fasteners or temporary clips. The surfaces are suitably clean and substantially free of foreign materials, for example fats, oils and water. The complementary surfaces may become adhered together relatively quickly so allowing the bonded assembly to be handled, for example on an automobile production line. The adhesive suitably continues to cure to provide maximum bond strength and this may take a period of hours.

The process conditions employed in bonding the structural member and reinforcing member together may vary according to the specific adhesive employed.

By way of illustration only, an adhesive comprising methyl methacrylate as the polymerisable component and an organoborane/amine complex as herein described may be applied to a structural member comprising polypropylene which has not been pre-treated, mixed with a curing component and left for a period of 1 to 10 minutes, prior to bringing a steel reinforcing member brought into contact with the structural member. The adhesive suitably bonds the two members

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sufficiently within 10 to 30 minutes after curing is initiated to allow the assembly to be handled. Subsequently, the adhesive continues to cure to provide a bond of maximum strength after 10 to 30 hours. The process is suitably carried out at ambient temperature.

5       As desired, mechanical fixing may be employed in addition to adhesive bonding to hold the structural member and the reinforcing member together.

The invention is described with reference to the accompanying Figures in which:

10       Figure 1 shows a perspective view of a structural member and a reinforcing member prior to assembly;

Figure 2 shows a perspective view of a part of a bonded automobile assembly;

Figure 3 shows a cross-section of the assembly of Figure 2; and

15       Figure 4 shows a cross-section of an alternative design of assembly to that shown in Figure 3.

In Figure 1, a structural member (1) and a reinforcing member (2) are shown prior to bonding together in accordance with the method of the invention.

Figure 2 shows the members (1) and (2) bonded together after assembly.

20       The structural member (1) is made of a moulded plastics material having a low energy surface and suitably is made of polypropylene or polyamide and typically is produced by compression moulding or injection moulding. The reinforcing member (2) is typically made of steel or aluminium.

25       The structural member (1) and the reinforcing member (2) are shaped as desired according to the design of the automobile and are provided with complementary surfaces (3) and (4) such that the members (1) and (2) fit snugly together and the invention enables the members (1) and (2) to be assembled after being produced.

30       Adhesive is applied to part or all of the complementary surface (3) and/or (4) and the reinforcing member (2) and the structural member (1) are brought into contact by relative movement towards each other in the direction A so that the

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complementary surfaces (3) and (4) abut one another. The adhesive is then cured or allowed to cure to provide a bonded assembly according to the invention, a part of which is as shown in Figure 2.

Figure 2 indicates a plane B-B through which a cross-section illustration is shown in Figure 3. In Figure 3, the reinforcing member (2) has a shallow channel (5) the inside of which defines the complementary surface (4) into which the complementary surface (3) of the structural member (1) is located in manufacturing the assembly. Adhesive is placed on at least part of the complementary surface (3) and/or (4) prior to assembly and forms the bond by which the members (1) and (2) are adhered.

The structural member (1) is also provided with side channels (6) and (7) and the reinforcing member (2) is provided with lips (8) and (9) which engage with the side channels (6) and (7) in a complementary manner. The surfaces of the channels (6) and (7) and lips (8) and (9) may be bonded by the provision of adhesive between the respective surfaces. Alternatively, these surfaces may not be bonded but in any event provide physical abutment between the respective parts of the structural member (1) and the reinforcing member (2) to enhance resistance to impact in the direction C, that is from the front of the automobile and to provide improved alignment between the members (1) and (2) during assembly.

Figure 4 shows a cross section of an assembly according to the invention of a different design to that shown in Figure 3. The structural member (1) and the reinforcing member (2) are aligned and adhered along complementary surfaces (3) and (4). Physical abutment of the members (1) and (2) along lips (10) and (11) and (12) and (13) respectively provide enhanced resistance to impact.

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Claims

1. A method for producing an automobile assembly comprising a structural member made of a moulded plastics material having a low energy surface and a reinforcing member attached to the structural member, the members having complementary surfaces, which comprises applying an adhesive to the complementary surface of the structural member and/or reinforcing member, bringing the complementary surfaces of the reinforcing member and structural member into contact and allowing the adhesive to set so as to bond the structural member and reinforcing member together wherein the adhesive is capable of bonding to a low energy surface plastic.
2. A method according to claim 1 in which the low energy surface plastics material has a surface energy of less than  $45 \text{ mJ/m}^2$ .
3. A method according to any one of claim 1 and claim 2 in which the plastics material comprises a homopolymer selected from a polyolefin, a polystyrene and a polyamide or a copolymer.
4. A method according to any one of the preceding claims in which the plastics material comprises fibre.
5. A method according to claim 4 in which the fibre is selected from short glass fibre, long glass fibre, short natural fibre or long natural fibre.
6. A method according to any one of the preceding claims in which the plastics material is selected from short glass fibre filled polypropylene, long glass fibre filled polypropylene, glass filled polyamide and glass filled polyamide alloys.

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7. A method according any one of the preceding claims in which the reinforcement is made of steel and/or aluminium.

5 8. A method according to any one of the preceding claims which comprises applying the adhesive directly to the surface of the structural member without treatment or priming of the said surface.

10 9. A method according to any one of the preceding claims in which the structural member and reinforcing member are bonded together by a continuum of adhesive along the complementary surfaces on the two members.

15 10. A method according to any one of the preceding claims in which the reinforcing member comprises contours or channels which are complementary with the surface of the structural member so as to provide resistance to stress by means of adhesion and/or abutment between the structural and reinforcing member.

20 11. A method according to any one of the preceding claims in which the adhesive comprises a polymerisable composition.

25 12. A method for producing an automobile assembly comprising a structural member made of a moulded plastics material having a low energy surface and a reinforcing member attached to the structural member, the members having complementary surfaces, which comprises providing an adhesive comprising a polymerisable composition, contacting together the components of the composition under conditions to initiate polymerisation, applying the adhesive to the complementary surface of the structural and/or reinforcing member, bringing the complementary surfaces of the reinforcing member and structural member into contact and curing the adhesive whereby the said members bond together.

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13. A method according to any of claim 11 and claim 12 in which the polymerisable composition comprises an organoborane/amine complex and one or more of monomers, oligomers or polymers having olefinic unsaturation which is capable of polymerisation by free radical polymerisation.

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14. A method according to claim 13 in which the polymerisable composition further comprises a compound which causes the said complex to disassociate so as to release the organoborane to initiate polymerisation of one or more of monomers, oligomers or polymers having olefinic unsaturation.

10

15. A method according to any one of claim 13 and claim 14 in which the amine part of the organoborane/amine complex is selected from the group of amines having an amidine structural component; aliphatic heterocycles having at least one nitrogen in the heterocyclic ring; primary amines which in addition have one or more hydrogen bond accepting groups wherein there are at least two carbon atoms between the primary amine and the hydrogen bond accepting group; and conjugated imines.

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16. A method according to claim 15 in which the amine is selected from dimethylaminopropyl amine, methoxypropyl amine, dimethylaminoethylamine, dimethylaminobutylamine, methoxybutyl amine, methoxyethyl amine, ethoxypropylamine, propoxypropylamine, amine terminated polyalkylene ethers (such as trimethylolpropane tris(poly(propyleneglycol), amine terminated)ether), aminopropylmorpholine, isophoronediamine, and aminopropylpropanediamine.

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17. A method according to any one of claims 13 to 16 in which the organoborane part of the organoborane/amine complex is selected from a trialkyl borane and an alkyl cycloalkyl borane.

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18. A method according to claim 17 in which the organoborane is selected from tri-ethyl borane, tri-isopropyl borane and tri-n-butylborane.

19. A method according to any one of claims 13 to 18 in which the molar ratio  
5 of amine compound to organoborane compound is from 1.0:1.0 to 3.0:1.0

20. An automobile assembly comprising a structural member made of a moulded plastics material having a low energy surface and a reinforcing member attached to the structural member, the structural member and reinforcing member  
10 having complementary surfaces and being attached by means of an adhesive, which is capable of bonding to a low energy surface substrate, on at least part of one or both of the complementary surfaces.

21. An automobile assembly comprising a structural member made of a  
15 moulded glass filled polypropylene and/or glass filled polyamide having a surface energy of less than  $45 \text{ mJ/m}^2$ , and a reinforcing member made from steel, zinc and/or aluminium attached to the structural member, the structural member and reinforcing member having complementary surfaces and being attached by means of an adhesive which is capable of bonding to a substrate having a surface energy  
20 of less than  $45 \text{ mJ/m}^2$  disposed between at least part of the complementary surfaces so as to bond them together, the adhesive being derived from a polymerisable composition comprising

i) an organoborane/amine complex;  
ii) one or more of monomers, oligomers or polymers having olefinic  
25 unsaturation which is capable of polymerisation by free radical polymerisation;  
and, optionally

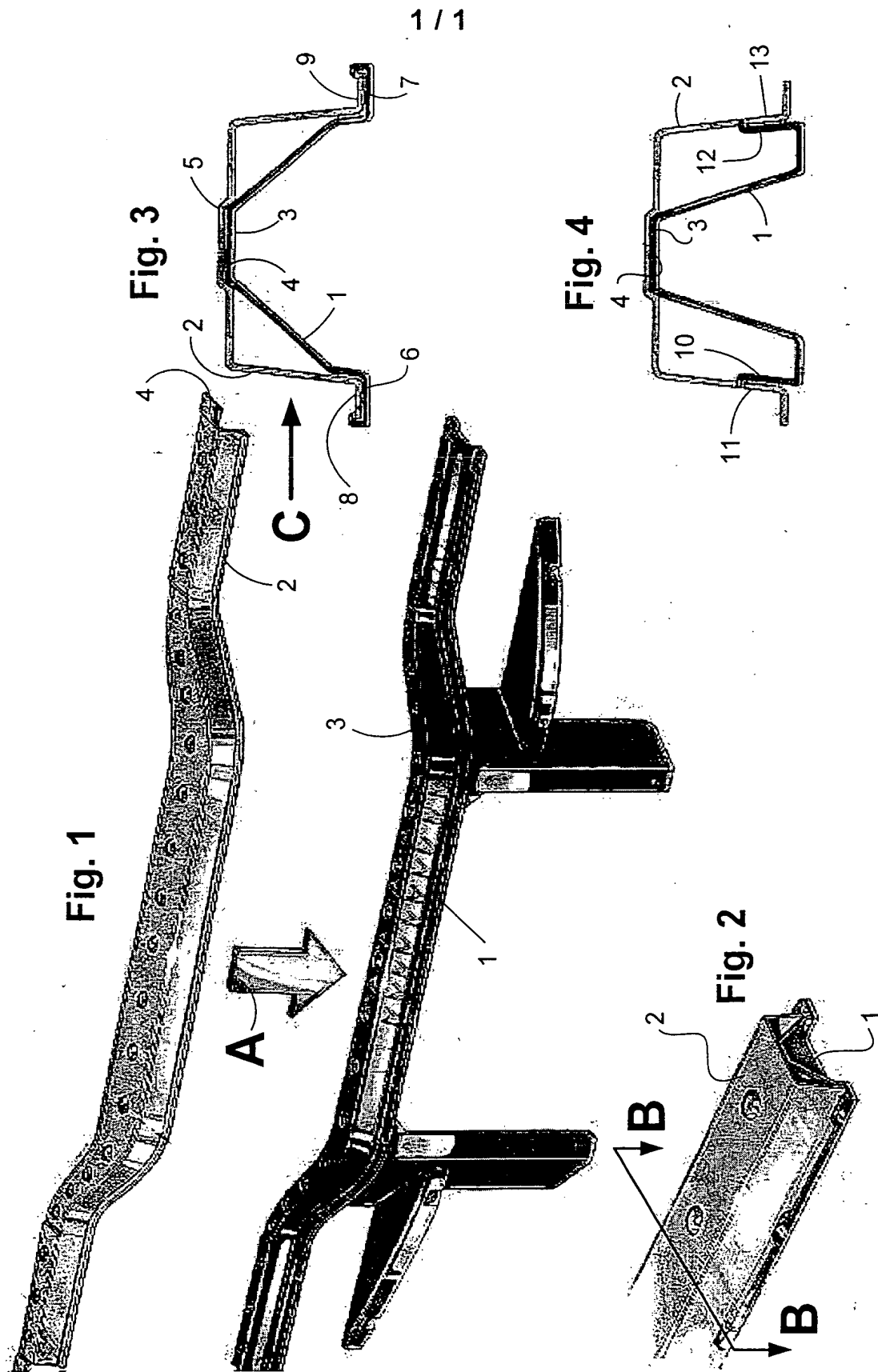
iii) a compound which causes the said complex to disassociate so as to release the borane to initiate polymerisation of one or more of monomers, oligomers or polymers having olefinic unsaturation.

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Abstract

A method for making an automobile assembly having a moulded plastics structural member and a reinforcing member in which a polymerisable adhesive is employed to bond the two members together and an automobile assembly having a bonded structural member and a reinforcing member are disclosed.

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